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van Schaik, A.B.T.M.; de Groot, H.L.F.

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Henri L.F. de Groot

Vrije Universiteit
De Boellaan 1105
1081 HV Amsterdam
The Netherlands

Anton B.T.M. van Schaik

Tilburg University
PO Box 90153
5000 LE Tilburg
The Netherlands
schaik@kub.nl

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We present a two-sector endogenous growth model of a closed economy with a dual labour market resulting from the presence of an effort extraction function in one sector. Effort of workers can be influenced by pay and monitoring. This results in an endogenously determined non-competitive wage differential between sectors and a monitoring intensity which is an important source of fixed costs for the firm. Growth is driven by intentional investments in R&D performed in the high-tech and high-wage sector. Unemployment is determined by the costs and benefits of waiting for a high-paid job. The benefits consist of entry in the high-wage sector. The costs are, among others, dependent on the rate of growth and the generosity of the social security system. The characteristics of the model are analyzed for different regimes of entry behaviour of firms. The model is characterized by a two-sided negative relation between unemployment and growth. Labour market institutions of which the organization of work and social security systems will explicitly be considered are shown to be important for the wage structure, growth, and unemployment.

1 Introduction

Wages differ considerably across broad sectors of the economy, even after controlling for age, education, occupation, gender, and workplace characteristics (*cf.* OECD (1994)). There are certain common elements in the estimates of these differences for a number of countries, e.g., manufacturing preeminently being *the* large sector paying a relatively high non-competitive wage premium, whereas the agricultural sector pays the lowest wages. The apparent willingness of employers in imperfectly competitive product markets to share rents with their workers introduces friction in the market mechanism: the unemployed may prolong their job search in the hope of entering high-wage sectors, and workers displaced from these sectors may have very high replacement rates and hence very high reservation wages when benefits are based on previous earnings (*cf.* Kletzer (1992)). In this view, unemployment is determined by outweighing the costs and benefits of waiting for a high-paid job. The first purpose of this chapter is to address these costs and benefits in the context of an endogenous growth model characterized by a dual labour market and optimally determined investment decisions in R&D. This allows us to study the relation between endogenous growth and unemployment in a general equilibrium framework. The analysis will be performed under both the regime of *free* and *blocked* entry.

The starting point of the project reported on in this paper is an endogenous growth model with a traditional and a high-tech sector. The duality of the economy will be argued to result in a segmented non-Walrasian labour market. Our model predicts that relative nominal wages are rigid. Labour is homogeneous, but employers in the high-tech sector are willing to pay efficiency wages for rent-sharing reasons. Thus, workers obtain a sector-specific wage rate. The existence of these rents in the imperfectly competitive high-tech sector of the economy is the benefit that gives people an incentive to wait for high-paid jobs. We generalize the well-known theoretical concept of an efficiency wage relation, in which only the wage rate features, by introducing the concept of an effort-extraction function (see also Bowles (1985)). The basic idea here is that employers have several means of 'extracting' effort from their employees. One is by monitoring and supervising the effort of employees, another is to pay relatively high wages. Introducing this basic idea in this paper allows us to study the effects of for example different organizations of work by firms on growth and unemployment in a consistent framework. Firms will optimally set the wage and monitoring intensity as to maximize their profits. This is shown to result in a trade-off between paying high wages and intensive monitoring. The monitoring intensity and wage level that result from this optimizing behaviour are shown to be crucial for both the growth and unemployment performance of an economy.

Our model deviates from the available literature on growth and unemployment in several respects. Firstly, our focus is mainly on distortions in the supply of labour causing equilibrium unemployment, whereas most of the available studies focus on distortions in demand. Secondly, we model unemployment as resulting from (extended) efficiency wage considerations playing a role in one sector only. Thirdly, we address the problem in a general equilibrium model with a segmented labour market, characterized by endogenously determined non-competitive wage differentials. Finally, we explicitly model growth as requiring (research) labour, where the intensity with which R&D is performed is determined on the basis of optimizing behaviour of firms. This way of modelling yields an additional (negative) feedback of growth on unemployment.

We proceed as follows. Section 2 presents the model. It discusses in turn household behaviour, firm behaviour and the labour market of the model. Section 3 solves the model under two alternative regimes of entry in the high-tech sector. Section 4 looks in detail at the properties of the model in the benchmark regime where free entry and exit prevails in the high-tech sector. It discusses the consequences for growth and unemployment of institutionally determined differences in effort extraction functions (capturing different ways of organizing work) as well as the consequences of changes in the generosity of social security systems. These exercises are repeated in section 5 but then under the regime of blocked entry. We present our conclusions in section 6.

2 A model of R&D and unemployment in a dual economy

The economy comprises two sectors. There is perfect competition in the product market for traditional goods and monopolistic competition in the product market for high-tech goods. Each firm in the high-tech sector produces a unique brand of the high-tech good. There are N high-tech firms, indexed $i = 1,...,N$. In section 3, we will elaborate on the determination of the number of firms. We assume that a high-tech firm only holds a negligibly small market share, so that competition is monopolistically à la Chamberlin. Growth stems from research done in the high-tech sector. Labour is homogeneous and can be employed in one of the two sectors or can be unemployed. Workers earn a sector-specific wage, while unemployed people get unemployment benefits. In this section, we will present the full model. Only the equations constituting the final model are numbered. Where there is no danger of confusion, time indices have been omitted.

2.1 Households

We assume identical infinite-lived households. Household behaviour is formulated as a three-stage budgeting problem. In the first stage, households maximize intertemporal utility[1]

$$U_0 = \int_0^\infty \frac{C_t^{1-\rho}}{1-\rho} e^{-\theta t} dt \quad \text{s.t.} \quad \dot{A}_t = r_t + I_{wt} - C_t P_{Ct},$$

where C is a composite good, $1/\rho$ is the intertemporal elasticity of substitution, and θ is the subjective discount rate. The dynamic budget constraint describes the development of financial assets (A) over time ($\dot{A}_t = \mathrm{d}A_t/\mathrm{d}t$). Households spend income on consumption (CP_C) and obtain income by working (I_w), and by receiving rental income (rA), over financial assets accumulated in the past.[2] Households have Cobb-Douglas preferences over the two goods. In the second stage of the optimization problem, they maximize

$$C = X^{\sigma} Y^{1-\sigma} \text{ s.t. } X\, p_X + Y\, p_Y = C\, p_C \; (0 < \sigma < 1),$$

where Y is the traditional good, X is a bundle of varieties of the high-tech good, and P_Y and P_X are the corresponding prices. In addition, households have CES-preferences over the high-tech goods (*cf.* Dixit and Stiglitz (1977)), so in the final step they maximize

$$X = \left[\sum_{i=1}^{N} x_i^{(\varepsilon-1)/\varepsilon} \right]^{\varepsilon(\varepsilon-1)} \quad \text{s.t.} \quad \sum_{i=1}^{N} p_{xi} = XP_X \left(\varepsilon > 1\right)$$

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1 All the maximizations are stated on a macroeconomic level. We think of each household as being made up of a continuum of individuals. We will return to the exact determination of household income in a later stage of the paper. For the moment it is important that, irrespective of how household income is determined, we can derive the consumption-savings decision.

2 In equilibrium, aggregate income from financial assets (rA) equals aggregate dividends paid by the firm. We will further elaborate on this in footnote 12 where we describe the savings-investment equilibrium.

where x_i represents the consumed quantity of the high-tech good of brand i, ε is the elasticity of substitution between any two high-tech goods, N is the number of available varieties of the high-tech good, and p_{xi} is the price of a single brand of the high-tech good of variety i.

The three-step maximization procedure yields *five* equations. In the first step, households decide how to divide total income between savings and consumption expenditures. This yields the Ramsey rule

$$\frac{\dot{C}}{C} = \frac{1}{\rho} \left[r - \frac{\dot{P}_C}{P_C} - \theta \right]. \tag{1}$$

This equation relates the growth rate of consumption to the determinants of the consumption-savings decision. It shows that the rate of growth is high if the real return on savings ($r - \dot{P}_C / P_C$) is large, if households are patient (θ is low), and if households are willing to substitute intertemporally (1/ρ is high).

In the second step, households decide how to divide the income they want to spend on consumption expenditures between high-tech and traditional goods. Given the Cobb-Douglas specification chosen above, this results in

$$\frac{Y P_Y}{1 - \sigma} = C P_C \quad \text{or} \quad \frac{Y P_Y}{X P_X} = \frac{1 - \sigma}{\sigma}, \tag{2}$$

$$P_C = \left(\frac{P_X}{\sigma} \right)^{\sigma} \left(\frac{P_Y}{1 - \sigma} \right)^{1-\sigma}. \tag{3}$$

Equation (2) tells us that a fixed fraction 1-σ of aggregate consumption expenditure CP_C is spent on traditional goods and a fixed fraction σ is spent on high-tech goods. Equation (3) is the definition of the macroeconomic price index.

In the last step, households decide how to divide the income they want to spend on high-tech goods among the N varieties of this good that are available. This yields the demand for a single variety of the high-tech good

$$x_i = X \left(\frac{p_{xi}}{P_X} \right)^{-\varepsilon}, \tag{4}$$

$$P_X = \left[\sum_{i=1}^{N} p_{xi}^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}. \tag{5}$$

The price-elasticity of demand for any variety of the high-tech good is thus equal to ε. From now on we employ the assumption of symmetry across firms in the high-tech sector, so that we may drop the subscript i. Hence, $X = xN^{\varepsilon/(\varepsilon-1)}$ and $N = XP_X/xp_X$. Notice that, after employing the symmetry assumption, the equation for the circular flow (2) can be written as $YP_Y/Nxp_x=(1-\sigma)/\sigma$.

2.2 Firms

The traditional sector exhibits unitary labour productivity

$$Y = L_Y. \tag{6}$$

L_Y stands for the number of workers employed in this sector and Y is the production of traditional goods. Under perfect competition, the price of a traditional good equals labour cost

$$P_Y = w_Y, \tag{7}$$

where w_Y denotes the wage rate in the traditional sector.

High-tech firms employ direct labour (L_x) with labour productivity h and effort e, to produce x units of output

$$x = e\, h\, L_x. \tag{8}$$

According to this equation, the overall productivity of direct labour (x/L_x) is composed of two factors, each determined differently. With respect to the effort (e), we assume the existence of a generalized version of the efficiency wage relation that we used in Van Schaik and De Groot (1998). We will further label this relation the effort-extraction function. The effort of a worker in the high-tech sector crucially depends on two factors. The first is the wage he earns (w_T) relative to the wage a worker earns in the traditional sector (w_Y). The second is the (effective) amount of labour employed for monitoring or supervision ($S \equiv eL_s$)

$$e = -a + c\left[\frac{w_T}{w_Y}\right]^{\gamma_1} S^{\gamma_2} \quad \left(0 \le \gamma_2 < \gamma_1/\varepsilon < 1/\varepsilon\right), \tag{9}$$

where γ_1 and γ_2 are the effort-wage and effort monitoring elasticity, respectively.[3] We call this the 'supply of effort'.[4] Following Akerlof (1982), the main reason in our model for high-tech firms to pay efficiency wages is based on sociological considerations. The idea is that each worker has a certain perception of the amount of effort that a 'fair' employer can ask from him. The employer can influence this fair amount of effort by changing the wage he pays. The more he pays, the higher the worker's notion of the fair amount of effort to be supplied to the employer. By paying high wages, the firm is thus able to raise the norms of a fair working day and the fair amount of effort to be supplied in exchange for that wage.

The importance of this type of sociological consideration in explaining various phenomena in the labour market is increasingly acknowledged (see, e.g., Fehr, Kirchsteiger and Riedl (1993), Kahneman, Knetsch and Thaler (1986), and Solow (1980)). The assumption that the efficiency wage considerations are only present in the high-tech sector is related to the prevailing imperfect competition in this sector. As profits are made in this sector only, workers may find it fair to share in these profits and hence ask for a higher wage. In that case, it may be in the interest of the profit-maximizing firm to offer a higher wage. This matches with the empirical literature in which the relation between the operation of an efficiency wage relation and some characteristics of the sector like the size of the firm, capital intensity or kind of competition, has been investigated (e.g., Arai (1994), Brown and Medoff (1989), Dickens and Katz (1987), Gera and Grenier (1994), Krueger and Summers (1988), and Van Reenen (1996)). In these studies, evidence is found for a significant wage premium for those people working in large, innovating firms and in firms that operate in situations of imperfect competition. This research has also revealed that (i) there is an interindustry wage structure that is significant and persistent over time and (ii) this wage structure cannot be explained solely on the basis of standard competitive factors as differences in skills, working conditions, *etc.* The second factor that positively influences the effort exerted by workers is the monitoring intensity (see also Bowles (1985)). We conceive the elasticities of the effort-extraction function as an important

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[3] We use this terminology for presentational convenience. The 'true' or 'correct' elasticities are endogenous due to the constant term a in the effort extraction function and they are equal to $\gamma_i\Omega/(-a+\Omega)$, where $\Omega \equiv c(w_T-/w_Y)^{\gamma 1}S^{\gamma 2}$.

[4] In the special case where γ_2=0, firms will be shown to employ no monitoring labour so S=0. For reasons of continuity, we assume that $S^{\gamma 2}$ is equal to one when γ_2=0 (x^x approaches 1 if x approaches zero from above).

institutional characteristic of the economy. They are characteristic of the way work is being organized within firms. The importance of institutional and organizational factors on the effort of workers has been stressed in (historical) studies on the relation between economic institutions and economic performance. The following passage (Lazonick (1991, p. 35)) is instructive:

> *To overcome restrictions of output and encourage workers to apply their effort to further the goals of the enterprise, employers had to assure the workers that promises of higher wages, better work conditions, and employment stability would be kept. Most capable of keeping such promises were those corporations that had already attained competitive advantage in their product markets. It was these corporations that were already generating value gains that could be shared with workers to an extent that other, less advantaged corporations could not. The most effective way to implement these incentives was by promising hard-working, loyal workers long-term employment security and a rising standard of living both on and off the job.*

The variable *h* can be affected by the firm by doing R&D. Assuming that there is no uncertainty with respect to investment in knowledge, employing L_r units of research labour yields an increase in technology equal to

$$\dot{h} = \xi \; h \; e \; L_r \; , \tag{10}$$

where *h* stands for the stock of knowledge a firm possesses (and which has been built up in the past), and $\xi(>0)$ is a productivity parameter. This specification of the knowledge base implies that knowledge is completely internal to the firm.[5] Finally, firms have to employ a fixed amount of labour in efficiency units (*F*) before being able to produce. One may think here of a fixed amount of management required before production can be started. So we require $F \equiv e\,L_f$.

In maximizing present discounted value, high-tech firms decide about labour input in

[5] Alternatively, we could assume that knowledge is only partly internal to the firm. As shown in Van Schaik and De Groot (1998), this does not affect the qualitative results. When knowledge is not completely internal to the firm, the incentive to engage in research is less, as the firm cannot fully appropriate the benefits that are generated through the research. This leads to a lower intensity of research (and therefore a lower growth rate) than when there are no knowledge spillovers.

the production department (L_x), labour input in the research department (L_r), the wage rate (w_T), and the monitoring intensity (S). This optimization leaves us with *five* equations capturing the First Order Conditions of the firms' optimization problem (see Appendix A for a derivation). In this approach, we determine the input of research labour on the basis of intertemporally optimizing behaviour of the firm. The first equation shows the wage-setting behaviour. Firms will pay higher wages as long as the increase in benefits related to the increase in efficiency more than offsets the increase in cost in the form of a higher wage bill. This comes down to the well-known Solow condition[6]

$$\frac{\partial e}{\partial w_T}\frac{w_T}{e} = 1 . \tag{11}$$

For the monitoring intensity, we derive

$$\frac{\partial e}{\partial S}\frac{S}{e} = \frac{L_s}{L_x + L_r + L_s + L_f} < 1 . \tag{12}$$

Firms increase their monitoring intensity as long as the marginal revenue of doing so exceeds the marginal cost. This results in an equilibrium effort-monitoring elasticity that is smaller than one (see footnote 3). So a one percent increase in the monitoring intensity only needs to result in a less than one percent increase in effort since this higher effort not only applies to the monitoring labour itself but also to production workers, researchers and managers. Combining these two conditions and using the endogenous effort-wage and effort-monitoring elasticities (see footnote 3), we can derive

$$e = \frac{a\gamma_1}{1-\gamma_1}, \omega \equiv \frac{w_T}{w_Y} = \left[\frac{a}{c(1-\gamma_1)S^{\gamma_2}}\right]^{\frac{1}{\gamma_1}} \text{ and } \frac{L_s}{L_x + L_r + L_s + L_f} = \frac{\gamma_2}{\gamma_1} .$$

[6] In Van Schaik and De Groot (1998) we assume that effort-extraction considerations only apply to production workers. Here, we assume that they apply to all high-tech workers. One can argue about the most appropriate assumption. In any case, only applying efficiency wage considerations to production workers yields a 'modified Solow condition'. According to this modified Solow condition, the endogenous effort-wage elasticity is larger than one in equilibrium. Increasing the wage by one percent should be accompanied with a more than one percent increase in effort, as the higher wage also has to be paid to research labourers and managers/fixed labour (of which the productivity is not affected by the wage setting behaviour).

This result reveals that in maximizing their profits, firms make a trade-off between eliciting effort via paying high wages (high ω) and via intensive monitoring (high S). Depending on the relative effectiveness of the two available instruments, firms decide on how much to pay their workers and how much monitoring labour to employ. The amount of supervision labour as a fraction of the total labour force of a firm is equal to the ratio of the effort-monitoring and the effort-wage elasticity (γ_2/γ_1). An increase in firm size results in other words in an equiproportionate increase in the amount of supervisors.

The third equation describes price-setting behaviour. Given the market power of high-tech firms, they will simply put a mark-up over their wage cost

$$p_x = \frac{\varepsilon}{\varepsilon - 1} \frac{w_T}{eh} \ . \tag{13}$$

This relation shows that real wages in the high-tech sector w_T/p_x increase with labour productivity h. Unit real labour costs w_T/ehp_x equal $(\varepsilon$-1$)/\varepsilon$ and are therefore invariant with respect to labour productivity growth. The mark-up is inversely related to the elasticity of substitution between any two high-tech goods. The closer these goods form substitutes, i.e., the higher ε is, the less market power firms have, and the lower the mark-up they can put on labour costs.

The fourth equation determines optimal research effort

$$w_T = p_h \ \xi \ e \ h \ . \tag{14}$$

In this formula, p_h is the shadow price of the level of technology h. It is a measure of the marginal value of an additional unit of h for the firm. According to this equation, a firm equalizes the marginal revenue of doing research (consisting of an increase in the level of technology a firm can use) with the marginal cost of R&D, i.e., the wage bill of a researcher. Combining equations (13) and (14) leads to $p_h/p_x=(\varepsilon-1)/(\xi\varepsilon)$. This relation shows that the price (of the input) of knowledge in terms of the price (of the output) of the final product will rise if it becomes relatively costly to generate new knowledge (ξ is low) and if high-tech goods form closer substitutes (higher ε).

Finally, we derive the dynamic equation

$$r = \xi \; e \; L_r + e \; L_x \; \frac{p_x}{p_h} \frac{\varepsilon - 1}{\varepsilon} + \frac{\dot{p}_h}{p_h} \; . \tag{15}$$

According to this equation, the marginal cost of an increase in *h* which consists of capital cost *r* should equal the marginal revenue of an increase in *h* which consists of an addition to the stock of knowledge, an increase in production, and a capital gains term, $\dot{p}_h / p_h$.

2.3 Equilibrium unemployment in a segmented labour market

An essential characteristic of the model is its segmented labour market. The effort-extraction function operating in the high-tech sector leads to primary sector workers receiving a non-competitive rent (ω>1).[7] The existence of these rents is at the heart of the analysis to follow. Each individual within a household is striving for the highest possible pay-off (in terms of present discounted value). Hence, all individuals would like to be employed in the high-tech sector.[8] The number of jobs in this sector is, however, limited since consumers want to spend their income on both high-tech and traditional goods (σ<1). We assume that at some exogenous rate δ, jobs in the high-tech sector become available. Upon being laid off, a worker faces two options. He can either decide to take a job in the traditional sector (these jobs are freely available), or he can join the pool of unemployed. In determining his optimal strategy, the worker has to take the following factors into consideration: (i) unemployment benefits are lower than the salaries in the traditional sector ($b<w_Y$), and (ii) the probability of being matched with a high-tech job when being in the traditional sector (αq) is lower than when being unemployed (q). The process of weighing the two options that laid off high-tech workers face results in an endogenously determined probability (η) of entering one of the two states (i.e., the state of unemployment or traditional sector employment). The outcome for this probability is such that ex-ante laid off workers (which are distributed randomly) are indifferent between the two options they face.

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[7] We restrict the parameters of the effort extraction function in such a way that a non-competitive wage differential results (i.e., $a/[c(1-\gamma_1)S^{\gamma 2}] > 1$).

[8] We are confronted in this model with the problem of incorporating a non-Walrasian labour market

Figure 1 presents a stylized interpretation of the labour market flows. The assumption that the unemployed have a higher probability of being matched with a job in the high-tech sector than workers in the traditional sector ($\alpha<1$) is important in our model and often used as a simple and useful working hypothesis in the literature on unemployment in dual labour markets (e.g., Bulow and Summers (1986), Burda (1988), Calvo (1978), Harris and Todaro (1970), McCormick (1990), Taubman and Wachter (1986)).

Figure 1 Labour-market flows

To formalize the determination of the labour market equilibrium, we now introduce three value functions (Bellman equations; see, e.g., Pissarides (1990)). Let V_Y, V_U, and V_T denote

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structure in a dynamic general equilibrium model (see, e.g., Danthine and Donaldson (1990), and Gali (1995) for a discussion of these problems in the context of a real business cycle model). Though the construction that we use here of having a representative household (making the consumption-savings decision) being composed out of a continuum of individuals aimed at achieving the highest possible pay-off (in terms of present discounted value) is admittedly somewhat artificial, it allows us to embody the relation between unemployment and endogenous growth in a general equilibrium framework.

the present discounted value of expected income streams of a worker in the traditional sector, an unemployed person, and a worker in the high-tech sector, respectively. The worker in the traditional sector earns a wage rate of w_Y and in unit time he expects to get a job in the high-tech sector with probability αq, which gives him a surplus of V_T - V_Y over his current position. V_Y thus satisfies

$$rV_Y = w_Y + \alpha q(V_T - V_Y)\,, \tag{16}$$

where rV_Y is, in a perfect capital market, the valuation put on having a job in the traditional sector (this job may be seen as an asset). This valuation equals the return on the traditional sector job. Similarly, we derive

$$rV_U = b\,w_Y + q(V_T - V_U)\,, \tag{17}$$

$$rV_T = w_T + \delta\eta(V_Y - V_T) + \delta(1-\eta)(V_U - V_T) \tag{18}$$

The workers discount their income at the nominal interest rate r as they can freely save and borrow in the financial market at the nominal interest rate. In equilibrium, it is required that the value of a job in the traditional sector equals the value of being unemployed

$$V_Y = V_U\,. \tag{19}$$

In addition, we impose two flow-equilibrium conditions, guaranteeing a constant allocation of labour over the three states

$$\delta\eta\, L_T = \alpha q\, L_Y\,, \tag{20}$$

$$\delta(1-\eta)L_T = qU. \tag{21}$$

Note that we can neglect flows between traditional-sector employment and unemployment because, in equilibrium, there is no incentive to alternate between equilibrium strategies that have been chosen.[9] Employment in the high-tech sector equals

[9] Take, for example, a worker in the traditional sector. Working in that sector has some value for him, and this value consists of current and future earnings. In equilibrium, this value is the same as the value that unemployed workers derive from being unemployed. Now suppose that a traditional sector worker moves to the pool of unemployed. The effect of that move is that the value of being unemployed goes down as more unemployed people compete for the available high-tech jobs, reducing the inflow rate into the high-tech sector q. The strategy of moving from traditional-sector employment to the unemployment pool will therefore not be chosen in equilibrium (and vice

$$L_T = N\left(L_x + L_r + L_s + L_f\right) \tag{22}$$

Finally, we have to impose a stock-equilibrium condition

$$L = L_T + L_Y + U, \tag{23}$$

so total labour supply L is either employed in one of the two sectors or unemployed. This labour market block of the model yields a relationship between the unemployment rate and the number of high-tech workers as a function of the relative wage differential ω, the unemployment benefit b, the acceptance rate of a worker from the traditional sector α, and the interest rate r.

By combining the above relations (equations (16)-(19)), we can derive the matching probability of an unemployed person with a job in the high-tech sector as a function of the rate of interest[10]

$$q = \frac{(1-b)(r+\delta)}{\omega(1-\alpha)-(1-\alpha b)}.$$

This reveals a positive relation between q and r. We can also derive a relation between the number of unemployed and the number of high-tech workers. This relation follows from the stock and flow equilibria on the labour market (equations (20)-(23))[11]

$$\frac{U}{L} = \frac{\delta + \alpha q}{q(1-\alpha)}\frac{L_T}{L} - \frac{\alpha}{1-\alpha}.$$

versa).

[10] An economically meaningful solution requires $0 < q < 1$ so $\omega > [(1-b)(r+\delta)+(1-\alpha b)]/(1-\alpha)$.

[11] To avoid corner solutions (in which all labour would be employed and divided over the two sectors) we restrict parameters to cases in which $U>0$.

According to this equation, the unemployment rate U/L is positively related to the number of high-tech workers and negatively related to the outflow rate out of unemployment (and thereby to the interest rate). This can be understood as follows. As more high-tech jobs become available (*ceteris paribus*), the number of high-tech jobs opening up as a result of lay-offs increases. For a given matching probability of unemployed people, this increases the attractiveness of waiting for a high-tech job as an unemployed job seeker. The unemployment rate will rise accordingly. An increase in the interest rate decreases the unemployment rate since a higher interest rate increases the importance attached to current payments. As being unemployed yields a relatively low current pay-off as compared to a traditional sector job, being in the traditional sector becomes relatively more attractive, reducing the unemployment rate (*ceteris paribus*). The model is thus characterized by a (partial) negative relation between growth (formally, the interest rate which, as we will see in the next section, positively depends on the growth rate) and unemployment. Unemployment and benefits are positively related. Higher benefits reduce the costs of waiting for a high-paid job and thus increase equilibrium unemployment. In section 4.4, we will look at the effects of the generosity of the social security system in the general equilibrium model.

The resulting unemployment in our model has to be thought of as wait unemployment. That is, part of the labour force is deliberately queuing up for the high-paid jobs. In the dual structure that we have in our model, it is impossible to call this type of unemployment either voluntary or involuntary. It is voluntary in the sense that the unemployed could, in principle, choose to be employed in the traditional sector. It is involuntary, however, as all the unemployed people are willing to accept a job in the high-tech sector, but are not offered such a job because of the rationing in that sector.

3 The steady state of the model

In this section, we will elaborate on the steady state equilibrium of the model. The system can be solved after defining a numéraire (alternatively, we could solve the model in relative prices), and after taking into account the definitions for the growth rates that link the levels of consumption, the price index of consumption, the level of technology and the shadow price of the level of technology with their respective growth rates. Furthermore, we need one more equation to determine the number of firms. The number of firms will either be taken as exogenous (the blocked entry regime) or as following from a zero-profit condition according to which firms enter or leave the market as long as excess profits are non-zero (the free entry regime). Both exercises/regimes are interesting in their own right and give rise to different conclusions. The system jumps to a steady state growth equilibrium as there are no predetermined rigidities and as there are constant returns to scale with respect to knowledge.

The blocked and free-entry equilibrium are characterized by non-negative excess profits in the high-tech sector

$$\pi = x\, p_x - (L_x + L_r + L_s + L_f)\, w_T \geq 0 \ ,$$

where the equality sign holds for free entry. Using the price equation (13) and the production function (8), this condition can be written as

$$\frac{\varepsilon}{\varepsilon - 1} \geq \frac{L_{xj} + L_{rj} + L_{sj} + L_f}{L_{xj}} \equiv R_j \ ,$$

where j indexes the prevailing kind of goods-market competition (*BE* represents blocked entry and *FE* represents free entry). R will further be denoted as the firm's 'fixed cost ratio'. It measures total firm size (L_x+L_r+L_s+L_f) in relation to the size of the production department (L_x). From the characterization of profits under the two respective regimes, we can thus derive $\varepsilon/(\varepsilon$-1) = $R_{FE} \geq R_{BE}$. This can be understood since making excess profits requires firms to be able to spread their fixed and quasi-fixed costs over a relatively large output, or, in other words, the size of the production department of the firms has to be large in relation to total firm size.

We will now derive the full solution of the model. To start with, notice that in the steady state it holds by definition that

$$g \equiv \frac{\dot{h}}{h} = \frac{\dot{x}}{x} = \frac{\dot{X}}{X} \text{ and } 0 \equiv \frac{\dot{Y}}{Y} \ .$$

Labour productivity in the high-tech sector grows at a constant rate, denoted by g. Output of high-tech goods also grows at rate g, while output of traditional goods is constant. In addition, from equations (2) and (3) it can be derived that the steady state circular flow equilibrium is characterized by

$$g = \frac{\dot{P}_Y}{P_Y} - \frac{\dot{p}_x}{p_x} = \frac{1}{1-\sigma}\left(\frac{\dot{P}_C}{P_C} - \frac{\dot{p}_x}{p_x}\right) = \frac{1}{\sigma}\,\frac{\dot{C}}{C}\ .$$

Since households spend a constant fraction σ on high-tech goods, the macroeconomic rate of growth is σg, whereas the relative price P_Y/p_x increases at the rate g. Taking the price of the traditional good as numéraire (P_Y=1), this implies that the price of a high-tech good decreases at the rate g.

The equilibrium growth- and interest rate can be found by confronting investment behaviour from the firms with savings behaviour from households.[12] Savings behaviour satisfies the Ramsey rule

$$g = \frac{r - \theta}{\sigma(\rho - 1)}\ .$$

This will be called the warranted or required rate of growth. A second relation between the rate of growth and the interest rate follows from producer behaviour[13]

$$g = r\left(R - 1 - \frac{\gamma_2 R}{\gamma_1}\right) - \xi F.$$

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[12] In this economy, aggregate income equals wage income I_w ($=w_T L_T + w_Y L_Y$) plus total dividends (ND). Dividends equal high-tech output (Nxp_x) minus production costs ($Nw_T(L_x+L_s+L_f)$) and are paid by high-tech firms. They equal income from financial assets rA. Investments by high-tech firms equal Nw_TL_r. Savings amount to aggregate income minus consumption expenditure ($I_w+ND-YP_Y-Nxp_x$). Using the definition for dividends, savings thus amount to Nw_TL_r. So, in equilibrium, aggregate investments equal aggregate savings.

[13] The dynamic equation governing producer behaviour (equation 15) can be written as $L_x=r/\xi e$ (using the steady state definition, the definition of the growth rate (equation 1), and equations (13) and (14) from which we derive that $\dot{p}_h/p_h=-g$). The effort wage elasticity is $\gamma_1\Omega/(-a+\Omega)$ (see footnote 3) and is equal to one (see equation 1) from which we can solve for Ω. Substituting this solution for Ω in equation (12), according to which $\gamma_2\Omega/(-a+\Omega)=L_s/RL_x$ (see also footnote 3), we derive that $\gamma_2/\gamma_1=L_s/(RL_x)$. It therefore holds that the `fixed cost ratio' R equals $1+g/r+R\gamma_2/\gamma_1+\xi F/r$. Rewriting this expression yields $g=r(R-1-\gamma_2R/\gamma_1)-\xi F$.

This will be called the planned rate of growth. The solution to the model is depicted in Figure 2. In this figure, the line *WW* represents the warranted rate of growth, while the line *PP* represents the planned rate of growth. The slope of these curves are $1/[\sigma(\rho\text{-}1)]$ and $R\text{-}1\text{-}\gamma_2 R/\gamma_1$, respectively.

Figure 2 Equilibrium growth and interest rate

Under free entry, R is known and equal to $\varepsilon/(\varepsilon\text{-}1)$, so the equilibrium growth and interest rate are easily found from Figure 2. Stability of the model is guaranteed if the warranted rate of growth intersects the planned rate of growth from above, which holds if $(R\text{-}1\text{-}\gamma_2 R/\gamma_1)>1/(\sigma(\rho\text{-}1))$. An economically meaningful steady state equilibrium is characterized by positive growth and interest rates. We can formulate this requirement as $\xi F>(R\text{-}1\text{-}\gamma_2 R/\gamma_1)\theta$. So for the growth and interest rates to be positive, the traditional fixed costs need to be large enough. Using that $R=\varepsilon/(\varepsilon\text{-}1)$ under free entry, these conditions simplify to $\xi F/\theta>[\gamma_1\text{-}\varepsilon\gamma_2]/[\gamma_1(\varepsilon\text{-}1)]>1/[\sigma(\rho\text{-}1)]>0$. Under blocked entry, we cannot determine the equilibrium growth- and interest rate of the model since R is not known. Additional information needed to determine the equilibrium solution is that labour market equilibrium holds. The details of the solution under the alternative regimes of entry can be found in Appendix B. In the next sections, we will discuss the properties of the model for the two distinguished regimes of entry.

4 The properties of the model under the regime of free entry

We consider the results of the free entry regime as a theoretical benchmark that applies in the highly 'stylized world' in which there are no barriers to entry or sunk costs that have to be incurred for entry to be feasible. The attention will be restricted to a discussion of the comparative static results that are obtained by changing the fixed costs (F), the generosity of the social security system (b), and the effort-monitoring elasticity (γ_2).

In the free entry regime, the equilibrium interest and growth rate follow from confronting the planned and warranted rate of growth as derived in section 3, and using $R=\varepsilon/(\varepsilon-1)$. This yields

$$r=\frac{\xi F\sigma(\rho-1)-\theta}{\sigma(\rho-1)Q-1} \text{ and } g=\frac{\xi F-\theta Q}{\sigma(\rho-1)Q-1} \text{ , where } Q=\frac{\gamma_1-\varepsilon\gamma_2}{\gamma_1(\varepsilon-1)}>0 \text{ .}$$

The equilibrium monitoring intensity and relative wage are then derived as

$$S=\frac{\varepsilon}{\varepsilon-1}\frac{\gamma_2}{\gamma_1}\frac{[\sigma(\rho-1)F-\theta/\xi]}{\sigma(\rho-1)Q-1} \text{ and } \omega=\left[\frac{a}{(1-\gamma_1)cS^{\gamma_2}}\right]^{\frac{1}{\gamma_1}} ,$$

and the equilibrium number of firms as

$$N=\frac{\frac{eL}{1-\alpha}}{\left[F\sigma(\rho-1)-\frac{\theta}{\xi}\right]\frac{\varepsilon}{\varepsilon-1}\left[\frac{\frac{1}{1-\alpha}+\frac{1-\sigma}{\sigma}\omega}{\frac{(\gamma_1-\varepsilon\gamma_2)\sigma(\rho-1)}{(\varepsilon-1)\gamma_1}-1}+\frac{\delta[\omega(1-\alpha)-(1-\alpha b)]}{(1-\alpha)(1-b)\left[\xi F\sigma(\rho-1)-\theta+\delta\frac{\gamma_1-\varepsilon\gamma_2}{(\varepsilon-1)\gamma_1}\sigma(\rho-1)-\delta\right]}\right]} .$$

An important remark with respect to the solution for the growth rate is that under free entry the equilibrium rate of growth does not depend on the size of the labour force L. This result is important in the light of the ongoing debate on the importance of scale effects in models of endogenous growth.

We now turn to the comparative static characteristics of the model. They are presented in Table 1, in which we make a distinction between the case in which $\gamma_2>0$, and $\gamma_2=0$.[14] An increase in the fixed cost requirement (F) unambiguously increases the growth and the interest rate. This is explained since large fixed costs will leave limited room for firms with non-negative profits. As a consequence, (remaining) high-tech firms will be larger and will have larger market shares. This increases their potential to spread the (quasi) fixed costs of R&D over a large output and thus increases their incentive to engage in R&D. This will result in large growth rates, and relatively large firms that employ more labour in all activities they perform (i.e., production, research, monitoring, and managing). This result reveals the Schumpeterian character of our model. In the case where $\gamma_2=0$, the increase in the interest rate will increase the cost of waiting for a well-paid job in the high-tech sector. Unemployment will thus decline and employment in both production sectors of the economy increases, whereas the number of high-tech firms declines (i.e. the increase in fixed costs forces some firms to leave the market). In the more general case where $\gamma_2>0$, the increased monitoring intensity (S) will be accompanied by a reduction in the relative wage (ω). We can unambiguously derive that employment in the high-tech sector increases (see Appendix B). In other words, the increase in firm size will always outweigh the reduction in number of firms. Due to the terms of trade effect that is associated with the decline in the relative wage, the ratio of traditional sector employment to high-tech employment will fall (so the economy becomes more high-tech in both absolute and relative terms). Also, wait-unemployment as a fraction of high-tech employment (U/L_T) declines due to the fact that (i) the relative wage rate declines which implies that the return to waiting is smaller and (ii) the interest rate is larger which increases the importance attached to current payments and thus makes waiting for a future high-paid job less attractive. Still, the effect on the level of traditional employment and unemployment cannot unambiguously be derived. Making the assumption that terms of trade effects do not dominate, traditional sector employment increases along with high-tech employment and unemployment declines (as in the case where $\gamma_2=0$).

[14] The case in which $\gamma_2=0$ yields the efficiency wage relation that is embodied in De Groot and Van Schaik (1998) in which only the relative wage rate (ω) features in the effort-extraction function and the monitoring intensity (S) is equal to zero.

Table 1 Comparative static results under free entry

	g	r	S	ω	L_x	L_r	L_s	L_T	L_Y	U	N	BB[15]
F	+	+	+/0	-/0	+	+	+/0	+	?/+	?/-	?/-	-
b	0	0	0	0	0	0	0	-	-	+	-	0
γ_2	+	+	+	n	+	+	+	v	v	n	- or v	-

Note: The signs in the cells indicate the signs of the derivatives of the respective variables with respect to the parameters under consideration. Wherever signs differ dependent on γ_2 larger or equal to zero, both effects are indicated: the first effect in a cell belongs to the case where $\gamma_2>0$. Of course, the last row only applies for $\gamma_2>0$. A 'v' indicates that the variable follows a U-shaped pattern, while a 'n' indicates that it follows a hump-shaped pattern. Details on the comparative statics w.r.t. γ_2 can be found in Appendix B.

There is by now considerable evidence that unemployment benefits affect unemployment rates (see OECD (1994)). Benefits should be conceived here in a broad way, also including coverage, duration, availability, administrative controls, *etc.* Not much is known, however, on the effects of unemployment benefits on economic growth. Most often, labour market institutions are assumed to have no growth effects at all (see chapter 1). In Table 1, the policy effects of a change in the generosity of the social security system for both unemployment and economic growth are given for the regime of free entry. The increased generosity of unemployment benefits increases the unemployment rate. This is caused by the decrease in the costs of waiting for a high-wage job. The effective supply of labour (L-U) is consequently decreased. This tends to decrease the average firm size in the high-tech sector and reduces the profitability of high-tech firms. As a consequence, some firms have to close down (N decreases). The variety of high-tech goods available to consumers is thereby reduced. This reduction continues until the high-tech firms make zero profits again (and are of the same size as they were initially). Both the high-tech and the traditional sector have shrinked.

15 BB represents the bureaucratic burden and is defined as $BB \equiv (L_s+L_f)/(L_x+L_r+L_s+L_f)=(L_s+L_f)/RL_x$.

This is an illustration of the dichotomy between the growth- and the labour-market block that characterizes the model under free entry (similar results are obtained with respect to the other parameters of the labour market block, i.e. α and δ). Labour market institutions do play a role, however, in determining the equilibrium number of high-tech firms, which is evident from the solution for N. By acting upon the costs and benefits of waiting for a high-paid job and consequently affecting equilibrium unemployment, labour market institutions influence the effective supply of labour (L-U). The smaller the effective supply of labour will be, the less room there is for profit-making firms and the smaller the number of high-tech firms will be. Labour market institutions have, in other words, no growth effects, but they do have level effects. These level effects influence the wellbeing of households as they have a taste for variety.[16]

Finally, we consider the effects of differences in the effort-monitoring elasticity. We consider differences in this elasticity as representative of differences in the way work is organized. In our view, these differences provide a potential explanation for observed differences in non-competitive wage differentials and the bureaucratic burden, but also for differences in the growth- and unemployment performance of an economy. In the remainder of this section we will analyze how growth, relative wages, unemployment and the sectoral allocation of labour develop as the effort-monitoring elasticity increases. Since we proceed with a focus on differences in the effort-supervision elasticity and assume γ_1 to be constant, we can consider the combinations of the relative wage and monitoring intensity that result from optimizing behaviour as combinations that are required to extract a certain (constant) level of effort from workers (note that the effort level is equal to $a\gamma_1/[1-\gamma_1]$ and is thus independent of γ_2). In our model, monitoring labour is an additional source of (quasi) fixed costs for firms. This implies that the more attractive it becomes for firms to use monitoring labour (i.e., the larger γ_2) as a means of eliciting effort from workers, the larger the fixed costs will be and, analogous to the logic with respect to increases in F, the larger the growth and interest rate will be. Along with this increase, the production- and research departments will become larger in size. The effects on the relative wage and the allocation of labour over the three states on the labour market are non-monotonous. As the effort-monitoring elasticity increases, firms will initially not

[16] The welfare properties of the model could be further examined, but this is beyond the scope of this paper.

only increase the amount of monitoring labour they employ, but also the (relative) wage they are willing to pay. In other words, the process of effort extraction initially becomes less effective as γ_2 increases in that both more monitoring labour and higher wages are required to extract a certain amount of effort. Only when the effort-monitoring elasticity surpasses some critical level, relative wages start to decline (see Appendix B; of course, for *given* elasticities, the result that high wages are traded off against high monitoring intensities stands upright).

The increase in the relative wage will initially make unemployment such an attractive option that unemployment will increase (even though the increased interest rate makes waiting relatively costly). As the growth rate increases along with γ_2, waiting will ultimately become so expensive that unemployment will decline. This is reinforced once the relative wage starts to decline. The development of the size of both the high-tech and the traditional sector follows a U-shaped pattern (the mirror-image of unemployment which follows a hump-shaped pattern; see Appendix B for details on the (relative) development of the allocation of labour). Ultimately, we are left with a picture in which countries with a low effort-monitoring elasticity are characterized by low growth, low unemployment, a low non-competitive wage differential, and a high bureaucratic burden. At the other end of the spectrum are countries with high growth rates, low non-competitive wage differentials, low unemployment rates, and a low bureaucratic burden. In intermediate cases, we have countries with high relative wages, high unemployment rates and intermediate rates of growth. The bottom-line of this exercise is that once we start to study empirically the relation between growth and unemployment in a cross-section of countries, one should not be too surprised to find a partial correlation between growth and unemployment that is neither clearly positive nor negative. Differences in institutions like the organization of work need to be controlled for in a proper and complete way in empirical studies.

A final general remark with which we conclude this section is that in all the comparative static exercises that we discussed, unemployment and high-tech employment move in opposite directions. This is important in the light of an often heard critique on the standard Harris-Todaro type of dual labour market models. Lindbeck and Snower (1991) criticize the Harris-Todaro types of models for this feature as it is inconsistent with empirical evidence. Our general equilibrium framework turns out to overcome this unattractive feature. This result shows the importance of a sound general equilibrium framework in which also demand and supply considerations are taken into account when analyzing the effects of, for example, policy changes (Lindbeck and Snower (1991) point at the importance of these general equilibrium effects but do not model them explicitly).

5 The properties of the model under the regime of blocked entry

It is most insightful to discuss the basic characteristics of the model under blocked entry by looking at the effects of a change in the number of high-tech firms. This exercise is also interesting from a policy point of view. It allows us to judge the common wisdom as expressed in the *OECD Jobs Study* (cf. OECD (1994, p. 23 and 53)) where it is proposed that 'Establishing a competitive environment could [...] improve job prospects by both eliminating wage premia and encouraging output expansion'. We will initially restrict attention to the case in which the effort-monitoring elasticity equals zero. A decrease in the number of firms increases the market share of each individual high-tech firm and increases its profitability. Each high-tech firm becomes larger in size. Fixed labour costs become a smaller part of the total wage bill.[17] As a consequence of these changes, each high-tech firm can afford more R&D outlays and the rate of growth increases accordingly (along with the interest rate). This result is largely due to the Schumpeterian flavour of the model. More concentration increases the profitability of firms. This leads to more R&D and a higher growth rate. We can furthermore show (see Appendix B) that equilibrium unemployment decreases and the traditional sector becomes larger in size. The decrease in unemployment is crucially driven by the increase in the interest rate which increases the cost of waiting for a high-paid job. The increase in the effective supply of labour (L-U) associated with the reduction in unemployment reinforces the positive consequences of an increase in concentration on economic growth. Under blocked entry, the rate of growth and equilibrium unemployment are thus simultaneously determined and are negatively related.

[17] See Appendix B for the formalities of this result, which says, in economic terms, that a concentrated industry is characterized by large firms with a relatively low fixed cost ratio. Mathematically deriving this result requires imposition of the condition $\delta R/\delta N>0$, which is the economically relevant case. This assumption implies, among others, that the number of firms under blocked entry is smaller than in the benchmark scenario of free entry (as $R_{BE}<R_{FE}$).

Conceiving a decrease in the number of firms as an increase in concentration, we can conclude that contrary to the common economic wisdom more concentration (for example due to the establishment of institutionally determined barriers to entry) increases economic growth and reduces equilibrium unemployment.

These results need some modification once we allow for a positive effort-monitoring elasticity. The previously derived results that the growth- and interest rate, and the production and research departments of firms become larger stand upright. In addition, firms will now employ more monitoring labour and relative wages will decrease (this is the trade-off between paying high wages and intensive monitoring). So reducing competition increases growth and decreases non-competitive wage differentials. The effect on unemployment of decreased competition will thereby be reinforced since the lower relative wages reduce the benefits of waiting for a high-paid job.[18]

In the remainder of this section, we will discuss the comparative static characteristics of the model by considering the effects of changes in b and γ_2, where unambiguous and monotonous results are obtained for the comparative statics with respect to the unemployment benefit b. They are reported in Table 2.[19]

[18] Unemployment will unambiguously decline if we assume that the effect on the intersectoral terms of trade will not be so large that it dominates the negative effect on the fixed cost ratio. In that case, the ratio of traditional sector employment and high-tech employment will go up and unemployment will unambiguously decline. This is further explained in Appendix B. Note that in the previous case where γ_2 was equal to zero, concentration did not affect the terms of trade and hence the ratio of traditional sector employment and high-tech employment unambiguously increased due to the lower fixed cost ratio (and the working of goods market equilibrium), resulting in lower unemployment.

[19] The results are obtained under the assumption that $\partial R/\partial N>0$ and $\partial(L_Y/L_T)/\partial R<0$. The latter assumption need not be made once we take the special case in which γ_2 is zero and the terms of trade is constant. We refer to Appendix B for an extensive explanation of these conditions and their implications. Numerical experimentation (see Appendix C) have lead to the conclusion that these assumptions are satisfied within a broad range of parameter values, so the conclusions we derive are reasonably robust.

Table 2 Comparative static results under blocked entry

	g	r	S	ω	L_x	L_r	L_s	L_T	L_Y	U	R	BB
b	-	-	-/0	+/0	-	-	-/0	-	-	+	+	-

Note: The signs in the cells indicate the signs of the derivatives of the respective variables with respect to the parameters under consideration. Wherever signs differ dependent on γ_2 larger or equal to zero, both effects are indicated where the first effect in a cell belongs to the case where γ_2>0.

We start the explanation of the results in Table 2 from the case in which γ_2=0. An increase in the unemployment benefit reduces the cost of waiting for a high-paid job, increasing unemployment and reducing both the high-tech and the traditional sector. As a consequence, high-tech firms become smaller in size and growth is depressed which further reinforces the increase in unemployment. Some modification of these results is again required once we allow for a positive effort-monitoring elasticity. When the unemployment benefit increases, firm size will unambiguously decline, which will be accompanied by a reduction in the monitoring intensity and an increase in the relative wage rate. This increase in the relative wage rate has two effects. It affects the intersectoral terms of trade and thereby positively affects the size of the traditional sector relative to the high-tech sector. And it also increases the attractiveness of waiting for a high-paid job since the non-competitive rent increases and thus tends to increase unemployment. If we assume (see Appendix B) that the intersectoral terms of trade effect is not that strong that it dominates the fixed cost effect, both the high-tech and the traditional sector will shrink in size following an increase in the unemployment benefit or the fixed cost requirement (as in the case where γ_2=0).

These results are of considerable interest in judging the policies advocated in many European countries in the 1970s. These policies can be characterized by increased generosity of the social security system. Our model in the case of blocked entry strongly suggests that policies, characterized by higher unemployment benefits lead to a reduction in the effective supply of labour, which may reduce the rate of growth. This effect reinforces the increase of unemployment as the accompanied decrease in the interest rate lowers the cost of waiting for high-wage jobs. Viewed against this light, the labour market policies set out in the 1970s turn out to have had damaging consequences for economic performance. Part of the success of the Dutch 'poldermodel' in the 1990s can be explained using the opposite logic. Reduced generosity of the social security system resulted in reduced unemployment and a relatively good performance in terms of economic growth.

We finally turn to the case of an increase in the effort-monitoring elasticity. Since it is hard to come up with analytical results in this case, we will describe the results of numerical experimentation with the model (see also Appendix C). The values of the variables of interest (the relative wage rate, the growth rate, the unemployment rate, and the size of both sectors) are depicted in Figures 3a - 3c as a function of γ_2 (where on the horizontal axis we indicate the percentage with which γ_2 deviates from its baseline value of 0.04).[20] As in the free-entry case, increases in γ_2 will result in increases in the monitoring intensity (S increases). However, under blocked entry, an increase in fixed costs (F or S) tends to result in a lower rate of growth since less labour remains within the firm for R&D activities. This lower growth rate along with the initial increase in the relative wage rate will unambiguously put an upward pressure on unemployment, leaving even less labour for R&D purposes and even further lowering the rate of growth. Only once the relative wage starts to decline following an increase in the effort-monitoring elasticity, a downward pressure on unemployment is exerted and unemployment will ultimately decrease. In addition, the decrease in the intersectoral terms of trade tends to make the high-tech sector larger in size. These two effects combined ultimately free up so much labour in the firms operating in the high-tech sector for productive purposes and R&D that the growth rate starts to increase. We emphasize that these comparative static results are mainly indicative for the complex relations between growth, relative wages, unemployment and the parameters of the model that emerge.

[20] The results depicted are based on the following parametrization of the model: ξ=0.02, F=0.8, θ=0.02, σ=0.6, ρ=6, ε=3, L=100, γ_1=0.7, γ_2=0.04, a=0.925, c=3, α=0.25, δ=0.05, and b=0.96.

Figure 3a Allocation of Labour

Figure 3b Relative wage *Figure 3c Growth rate*

6 Conclusion

In this paper, we presented a model for studying the interaction between equilibrium unemployment and long-term endogenous growth under different regimes of entry. The model can best be characterized as a dynamic general equilibrium model with a non-Walrasian labour market structure. Investment in R&D is a major source of fixed cost and therefore of excess profits in imperfectly competitive product markets. The innovative aspect of the paper is that incumbent firms are assumed to be willing to share excess profits with their workers due to the presence of an effort-extraction function. Firms trade off high wages against intensive monitoring. This results in a dual economy with high-paying jobs in the growth-generating high-tech sector and low-paying jobs in the traditional sector. Growth and unemployment are directly (partially) related for two reasons. Increased growth will be accompanied by an increase in the interest rate and thereby increase the cost of waiting for a job in the high-tech sector resulting in lower unemployment. Higher unemployment decreases the effective supply of labour and thereby tends to depress the scale of operation of individual firms, reducing the attractiveness of investing in R&D and lowering economic growth. This last effect turned out to be absent when free entry prevailed since the reduction of the effective supply of labour was accompanied with an equiproportionate decline in the number of firms, leaving market shares unaffected.[21] Growth and unemployment are thus inherently negatively related in the model.

We went on to study the effects of labour market policies (captured by the generosity of the social security system) and differences in the organization of work for the growth and unemployment performance of economies. The results turned out to be crucially dependent on the prevailing regime of entry. In the benchmark scenario, where all excess profits are eliminated by the process of entry and/or exit, labour market policies do have no effect on growth, whereas they have the expected effects on equilibrium unemployment. Changes in the way work is organized within firms turned out to affect growth and unemployment via various channels. The extent to which firms rely on paying high wages relative to intensive monitoring was shown to be an important determinant for both growth and unemployment. The more firms rely on paying high wages, the larger the non-competitive rents will be that workers are searching for, and hence the larger equilibrium unemployment will be. Intensive monitoring is a source of fixed costs for firms. Due to the Schumpeterian character of the model in which large market shares have a positive influence on the incentives of firms to engage in R&D, the

[21] This result depends on the modelling of the engine of growth in which in this paper *average* knowledge features instead of some measure of *total* knowledge. Generalizing the knowledge base by allowing the number of firms to feature in the engine of growth would result in growth being negatively dependent on the generosity of the social security system.

monitoring intensity is thus an important determinant of the rate of growth. We finally concluded that countries relying heavily on monitoring can thereby afford the payment of low relative wages in the process of effort extraction and are characterized by high growth, low unemployment, and a low bureaucratic burden.

As opposed to the benchmark scenario of free entry, we looked at a world in which the equilibrium number of firms is exogenously given. In this world, labour market policies affect both the equilibrium rate of unemployment *and* the rate of growth. Increased concentration was shown to have a positive effect on both growth and employment, as opposed to the commonly held belief. This result is due to the Schumpeterian character of our model. Differences in the organization of work affect growth and unemployment via various mechanisms. As in the free entry regime, countries that rely heavily on effort extraction via intensive monitoring are characterized by low relative wages, low unemployment and large growth rates.

This paper makes clear that controlling for labour market institutions in a broad sense, including factors related to for example the organization of work, the social security system, but also differences in the prevailing regime of entry, is of crucial importance when empirically studying the relation between growth and unemployment. The negative relation between growth and unemployment that we found in our theoretical model may remain unnoticed in empirical research due to cross-country differences that have not been taken into account. One should therefore not be too surprised that the partial relation between growth and unemployment is neither clearly positive nor negative (see also Bean and Pissarides (1993), Nickell and Layard (1997) for an overview of theoretical and empirical studies on growth and unemployment). Although an empirical investigation on the relation between growth and unemployment is beyond the scope of this paper, we think that this is an interesting way to go and may yield new insights.

Appendix A. Derivation of equations (4)-(15)

On the producer side of the model we assume that high-tech firms compete monopolistically. Each firm, producing a unique brand of the high-tech good, is assumed to maximize its present discounted value:

$$\max_{L_{rit},\, L_{xit},\, w_{xit},\, S_{it}} \int_0^{\infty} \left[x_{it}\; p_{xit} - (L_{xit} + L_{rit} + L_{sit} + L_{fit})\, w_{Tit} \right] e^{-rt}\, dt \,, \qquad \text{(A.1)}$$

subject to (time indices have been omitted for reasons of clarity)

$$x_i = h_i\, e_i\, L_{xi} \,, \qquad \text{(A.2)}$$

$$e_i = -a + c \left[\frac{w_{Ti}}{w_Y} \right]^{\gamma_1} S_i^{\gamma_2} \qquad \text{(A.3)}$$

$$\dot{h}_i = \xi e_i h_i L_{ri} \,, \qquad \text{(A.4)}$$

$$x_i = X \left(\frac{p_{xi}}{P_X} \right)^{-\varepsilon} , \qquad \text{(A.5)}$$

$$F_i = L_{fi} e_i, \qquad \text{(A.6)}$$

$$S_i = L_{si} e_i, \qquad \text{(A.7)}$$

The 'current value' Hamiltonian corresponding to this optimization problem is

$$H_{it} = x_{it}\; p_{xit} - \left(L_{xit} + L_{rit} + \frac{S_{it} + F_{it}}{e_{it}} \right) w_{Tit} + p_{hit}\; \xi\; e_{it}\; h_{it}\; L_{rit} \,, \qquad \text{(A.3)}$$

where p_{hi} is the shadow price of the level of technology h_i. This shadow price is a measure of the marginal value of an additional unit of h for the firm.

The first order conditions of this maximization problem are

$$\frac{\partial H}{\partial w_{Ti}} = \frac{\partial x_i}{\partial e_i}\frac{\partial e_i}{\partial w_{Ti}} p_{xi}\left(\frac{\varepsilon - 1}{\varepsilon}\right) - \left(L_{xi} + L_{ri} + \frac{S_i + F_i}{e_i}\right) + \frac{\partial e_i}{\partial w_{Ti}}\frac{w_{Ti}(S_i + F_i)}{e_i^2} + \frac{\partial e_i}{\partial w_{Ti}} p_{hi}\xi h_i L_{ri}$$

$$= h_i L_{xi}\frac{\partial e_i}{\partial w_{Ti}} p_{xi}\frac{\varepsilon - 1}{\varepsilon} - \left(L_{xi} + L_{ri} + \frac{S_i + F_i}{e_i}\right) + \frac{\partial e_i}{\partial w_{Ti}}\frac{w_{Ti}}{e_i}\left(\frac{F_i + S_i}{e_i}\right) + \frac{\partial e_i}{\partial w_{Ti}} p_{hi}\xi h_i L_{ri} = 0 \ , \tag{A.9}$$

$$\frac{\partial H}{\partial S_i} = h_i L_{xi} p_{xi}\left(\frac{\varepsilon - 1}{\varepsilon}\right)\frac{\partial e_i}{\partial S_i} - \frac{w_{Ti}}{e_i} + \frac{\partial e_i}{\partial S_i}\frac{(S_i + F_i) w_{Ti}}{e_i^2} + \frac{\partial e_i}{\partial S_i} p_{hi}\xi h L_{ri} = 0 \ , \tag{A.4}$$

$$\frac{\partial H}{\partial L_{xi}} = \frac{\partial x_i}{\partial L_{xi}} p_{xi} + x_i \frac{\partial p_{xi}}{\partial x_i}\frac{\partial x_i}{\partial L_{xi}} - w_{Ti} = e_i h_i p_{xi}\frac{\varepsilon - 1}{\varepsilon} - w_{Ti} = 0, \tag{A.11}$$

$$\frac{\partial H}{\partial L_{ri}} = -w_{Ti} + p_{hi}\xi e_i h_i = 0, \tag{A.12}$$

$$r p_{hi} = \dot{p}_{hi} + \frac{\partial H}{\partial h_i} = \dot{p}_{hi} + \frac{\partial x_i}{\partial h_i} p_{xi} + \frac{\partial p_{xi}}{\partial x_i}\frac{\partial x_i}{\partial h_i} x_i + p_{hi}\xi e_i L_{ri}, \tag{A.13}$$

We now invoke the symmetry assumption. From equation (A.11) it directly follows that firms engage in mark-up pricing (equation (13) in the text). Equation (A.12) yields the optimal R&D input (equation (14) in the text). Equation (A.13) is the dynamic equation governing the allocation of high-tech labour over time. Using equations (A.11) and (A.12) and rewriting yields equation (15) in the text. Finally, substituting equations (A.11) and (A.12) into equations (A.9) and (A.10) we get the set of 'Solow-conditions' (equations (11) and (12) in the text).

Appendix B. Solution of the complete model

The reduced system of equations from which we can solve the complete model consists of the equations[22]:

$$g = r\left(R - 1 - \frac{\gamma_2 R}{\gamma_1} \right) - \xi F \ , \tag{B.1}$$

$$g = \frac{r - \theta}{\sigma(\rho - 1)} \ , \tag{B.5}$$

$$L_T = NR\, L_x \ , \tag{B.6}$$

$$L_x = \frac{r}{\xi e}, \tag{B.4}$$

$$L_Y = \frac{1-\sigma}{\sigma} NL_x \frac{\varepsilon}{\varepsilon - 1}\omega, \tag{B.5}$$

$$U = \frac{\delta + \alpha q}{q(1-\alpha)} L_T - \frac{\alpha}{1-\alpha} L, \tag{B.6}$$

$$q = \frac{(1-b)(r+\delta)}{\omega(1-\alpha) - (1-\alpha b)}, \tag{B.7}$$

$$L = L_Y + L_T + U, \tag{B.8}$$

[22] Equation (B.5) is derived using goods-market equilibrium according to which spending on the available goods is divided according to $(1\text{-}\sigma)/\sigma = YP_Y/(Nxp_x) = L_Y w_Y(\varepsilon\text{-}1)/(NL_x \varepsilon w_T)$.

$$e = \frac{a\gamma_1}{1-\gamma_1}, \tag{B.9}$$

$$\omega = \left[\frac{a}{(1-\gamma_1)cS^{\gamma_2}}\right]^{\frac{1}{\gamma_1}} = \left[\frac{a}{(1-\gamma_1)c\left(\frac{\gamma_2 Rr}{\xi\gamma_1}\right)^{\gamma_2}}\right]^{\frac{1}{\gamma_1}}. \tag{B.10}$$

The system is completed by the equation characterizing the prevailing regime of entry which is

$$R = \frac{\varepsilon}{\varepsilon - 1} \tag{B.11a}$$

under free entry and

$$N = \overline{N} \tag{B.11b}$$

under blocked entry.

Combining the planned and warranted rate of growth (equations (B.1) and (B.2)) we can derive the equilibrium rate of growth and the interest rate as

$$g = \frac{\xi F - \theta\left(R - 1 - \frac{\gamma_2 R}{\gamma_1}\right)}{\left(R - 1 - \frac{\gamma_2 R}{\gamma_1}\right)\sigma(\rho - 1) - 1} \text{ and } r = \frac{\xi F\sigma(\rho - 1) - \theta}{\left(R - 1 - \frac{\gamma_2 R}{\gamma_1}\right)\sigma(\rho - 1) - 1}. \tag{B.12}$$

The number of production workers now follows from equation (B.4)

$$L_x = \frac{\frac{F\sigma(\rho - 1)}{e} - \frac{\theta}{\xi e}}{\left(R - 1 - \frac{\gamma_2 R}{\gamma_1}\right)\sigma(\rho - 1) - 1}. \tag{B.13}$$

Using equations (B.3), (B.5), (B.6), and (B.7), high-tech employment, traditional employment and unemployment can now be written as a function of the parameters of the model, the number of firms, N, the relative wage, ω, and R. Substituting the expressions for L_T, L_Y, and U into equation (B.8), we can solve for the equilibrium number of firms as a function of R and the relative wage (which can also be written as a function of R)

$$N = \frac{eL/(1-\alpha)}{\left[F\sigma(\rho-1)-\frac{\theta}{\xi}\right]\left[\frac{\frac{R}{1-\alpha}+\frac{1-\sigma}{\sigma}\frac{\varepsilon}{\varepsilon-1}\omega}{\left(R-1-\frac{\gamma_2 R}{\gamma_1}\right)\sigma(\rho-1)-1}+\frac{\delta R\left[\omega(1-\alpha)-(1-\alpha b)\right]}{(1-\alpha)(1-b)\left[\xi F\sigma(\rho-1)-\theta+\delta\left(R-1-\frac{\gamma_2 R}{\gamma_1}\right)\sigma(\rho-1)-\delta\right]}\right]} . \tag{B.14}$$

Comparative Statics under Free Entry

Under free entry, the equilibrium growth- and interest rate, the relative wage and the equilibrium number of firms follow from using the fact that R=ε/(ε-1). This gives rise to the equations given in the beginning of section 4. The comparative static characteristics as described in the text and in Table 1 with respect to r, g, S, L_x(=$r/\xi e$), L_r(=$g/\xi e$) and L_s=S/e are straightforwardly derived by taking first order derivatives. The comparative static results with respect to the bureaucratic burden can be derived by solving for the bureaucratic burden as

$$BB = \frac{L_s + L_f}{R\,L_x} = \frac{\gamma_2}{\gamma_1} + \frac{\left[R\frac{\gamma_1-\gamma_2}{\gamma_1} - 1\right]\sigma(\rho-1) - 1}{R\left[\sigma(\rho-1)-\frac{\theta}{\xi F}\right]} , \tag{B.15}$$

and taking derivatives with respect to the parameters under consideration. To consider the effects of a change in γ_2 on the relative wage as discussed in section 4, we derive from (B.10) that

$$\frac{d\omega}{d\gamma_2} = \frac{-\omega}{\gamma_1}\left[\ln S + \frac{\sigma(\rho-1)-(\varepsilon-1)}{\sigma(\rho-1)\left(\frac{\gamma_1-\varepsilon\gamma_2}{\gamma_1}\right)-(\varepsilon-1)} \right]. \qquad \text{(B.16)}$$

At low levels of γ_2, this derivative is positive ($\ln(S)$ tends to $-\infty$ as γ_2 approaches zero from above). So at small values of γ_2, ω is increasing in γ_2. The second order derivative is negative so eventually ω becomes a declining function of γ_2. The comparative static characteristics of ω are then easily derived as reported in Table 1.

We finally have to determine the comparative static results with respect to the allocation of labour and the number of high-tech firms. To derive the results we write labour market equilibrium using (B.3), (B.5), (B.6), (B.7), and $R=\varepsilon/(\varepsilon-1)$ as

$$\frac{L}{1-\alpha} = \frac{NRL_x}{1-\alpha} + \frac{1-\sigma}{\sigma}\frac{\varepsilon}{\varepsilon-1}\omega N L_x + \frac{\delta[\omega(1-\alpha)-(1-\alpha b)]}{(1-\alpha)(1-b)(r+\delta)} NRL_x . \qquad \text{(B.17)}$$

To study the comparative statics, we distinguish between $\gamma_2=0$, and $\gamma_2>0$. When $\gamma_2=0$, an increase in F increases the interest rate. Using equation (B.17), we then derive that NL_x increases, so L_T and L_Y increase, and thus unemployment increases. The decline in N follows from straightforward differentiation of equation (B.14). Using a similar procedure, the comparative statics w.r.t. b are derived. When γ_2 is positive, comparative static effects of an increase in F are less clearcut. Since the interest rate increases and the relative wage declines, we know from equation (B.17) that NL_x increases so high-tech employment increases. The effects on unemployment and traditional employment are ambiguous. In the economically most reasonable case where intersectoral terms of trade effects do not dominate, L_Y increases and unemployment declines. We can, however, not preclude a priori that traditional sector employment declines and unemployment increases. The effects of b do not depend on the sign of γ_2 since changes in b leave the relative wage rate unaffected.

The effects of changes in γ_2 on the allocation of labour are non-monotonous. We know that r is increasing in γ_2. We have also seen that ω reaches a maximum value at some γ_2. We define this value as γ_2^{ω}. Starting from this point, we will now derive the relative position of the peaks and/or troughs of the sectoral labour shares in several steps. The derivatives of variables of interest w.r.t. γ_2 at different values of γ_2 are summarized in Table B.1 that is constructed on the basis of the following reasoning:

(i) Using equation (B.17), we know that at γ_2^{ω}, $L_T(=RNL_x)$ is increasing since ω is constant and r is increasing. So by using goods-market equilibrium (equation 1), we can conclude that also L_Y is increasing in γ_2 at γ_2^{ω}. Unemployment is thus decreasing in γ_2 at γ_2^{ω}.

(ii) When $\gamma_2<\gamma_2^{\omega}$, both ω and r are increasing in γ_2. At low values of γ_2, the increase in the relative wage rate is strong relative to the increase in r, so NL_x is decreasing. At some value for γ_2 which we define as γ_2^{LT}, $L_T(=NRL_x)$ reaches a minimum. At this point, L_Y is increasing in γ_2 since ω is increasing. Unemployment is thus decreasing in γ_2 at γ_2^{LT}.

(iii) The strong increase in ω at low levels of γ_2 exerts an upward pressure on unemployment, where unemployment reaches a maximum at a point we define as γ_2^{U}. At this value, traditional sector employment is increasing in γ_2 since high-tech employment is decreasing.

(iv) L_Y reaches a minimum at γ_2^{LY} which must be to the left of γ_2^{LT}.

The effects on N follow by using that $N=L_T/RL_x=L_T\xi e/Rr$. At low values of γ_2, L_T is decreasing in γ_2, while r is increasing in γ_2, so N is unambiguously decreasing, until L_T starts to increase. From this point onwards, we cannot unambiguously conclude that N is decreasing in γ_2.

Table B.1 Derivative of variables of interest w.r.t. γ_2 at different values of γ_2

		γ_2^{LY}	<	γ_2^{U}	<	γ_2^{LT}	<	γ_2^{ω}	
ω	+	+	+	+	+	+	+	0	-
r	+	+	+	+	+	+	+	+	+
L_T	-	-	-	-	-	0	+	+	+
U	+	+	+	0	-	-	-	-	-
L_Y	-	0	+	+	+	+	+	+	+
N	-	-	-	-	-	-	?	?	?

Comparative Statics under Blocked Entry

Under blocked entry, we can solve for the 'fixed cost ratio' R by using equation (B.14), after substitution of equation 1 and the solution for the interest rate. For the special case where $\gamma_2=0$, analytical results are easily obtained, if we make the reasonable assumption that $\partial R/\partial N$ is positive.[23] This implies that as the number of firms increases, they shrink in size and fixed labour will form a larger and larger part of the firm's total employment. Economically, this is the most relevant case.

The comparative static results with respect to N reported on in section 5 can then be derived as follows. The decrease in R increases the growth rate, the interest rate, the number of production workers and the number of researchers. No clearcut conclusions can be derived with respect to the total number of high-tech workers. Nevertheless, we can conclude that unemployment decreases and traditional sector employment increases.[24] The comparative static results with respect to a change in the generosity of the social security system (b) follow straightforwardly from using the fact that $\partial N/\partial b$ is negative and using the implicit function theorem.

If we drop the assumption that $\gamma_2=0$, analytical results become harder to obtain. The reason is that both the relative wage and the monitoring intensity will be (more) responsive to a change in one of the parameters. This has effects on the rate of growth, the interest rate, the sectoral terms of trade and thereby on equilibrium unemployment. According to the same logic as in the case in which $\gamma_2=0$, we make the (economically reasonable) assumption that $\partial R/\partial N$ is positive. The comparative static results with respect to N reported on in section 5.5 can then be

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23 By straightforward calculation, it can be shown that $\delta > \frac{\xi F \sigma(\rho-1) - \theta}{\sigma(\rho-1)+1}$ is a sufficient condition for $\partial R/\partial N>0$. The economic intuition behind this condition is that the negative effect of an increase in R on r may not be too large. Otherwise, unemployment would be strongly positively affected, strongly decreasing the effective supply of labour and forcing some firms to shut down. In addition, extensive numerical simulations with reasonable parameter values confirm the robustness of $\partial R/\partial N>0$.

24 If the total number of high-tech workers decreases, unemployment decreases with certainty (the cost of waiting increase and the potential of entering the high-wage sector decreases). Consequently, traditional sector employment has to increase. If, on the other hand, the number of high-tech workers increases, NL_x has to increase (see equation 1) and, using goods-market equilibrium (equation 1), traditional sector employment has to go up. This must imply that unemployment decreases.

derived as follows. The decrease in R increases the growth rate, the interest rate, the number of production workers, the number of researchers, and the number of monitors. The relative wage rate goes down (use that $\partial(Rr)/\partial R<0$ so $\partial\omega/\partial R>0$). If we make the assumption that the effect of the decrease in the fixed cost ratio dominates the decrease in the relative wage, L_Y/L_T increases (divide equations (B.3) and (B.5)). There are then three remaining possibilities with respect to the sectoral allocation of labour: (i) employment in both sectors increases and unemployment decreases, (ii) high-tech employment remains constant, unemployment decreases and traditional sector employment increases, or (iii) high-tech employment decreases, unemployment decreases and traditional sector employment increases. We are certain, however, that traditional sector employment increases and unemployment decreases. The comparative static results with respect to a change in the generosity of the social security system (b) as reported on in section 5, follow straightforwardly from using the fact that $\partial N/\partial b$ is negative and using the implicit function theorem. This implies that the rate of growth and the interest rate decline, the amount of production-, research-, and monitoring labour declines, the high-tech sector becomes smaller, and the relative wage increases. Again assuming that the effect of the fixed cost ratio dominates the effect of the wage differential, L_Y/L_T decreases (divide equations (B.3) and (B.5)). It then straightforwardly follows that employment in both sectors decreases and unemployment increases.

Appendix C. Some numerical simulations

Free entry

In this appendix, we will perform some numerical experiments to get a feeling for the comparative static characteristics of the model and the sensitivity of the model with respect to parameter changes. We start from a set of base-line parameters that is given in Table C.1. These parameters result in g=3.176%, ω=1.08, U=10.99, L_T=51.69, L_Y=37.31, L_x=2.67, L_r=0.73, L_s=0.22, N=12.90 and q=0.127. Based on the constraints that we imposed in the main text ($0<q<1$, $U>0$, $g>0$, and stability of the model), we derived extreme bounds of the parameter values. These are given in Table C.1.

Table C.1 Base values parameters and extreme bounds

	Base	min	max		Base	min	max
ξ	0.02	0.0104	0.0323	γ_1	0.7	0.6925	0.9999
F (2)	0.8	0.4143	1.0536	γ_2 (7)	0.04	0	0.0501
θ	0.02	0.0048	0.0386	a	0.925	0.9018	∞
σ	0.6	0.5553	1	c	3	0.0001	3.0773
ρ	6	5.5606	∞	α	0.25	0.0001	0.3790
ε	3	2.1001	3.1320	δ	0.05	0.0186	1
L	100	0.0001	∞	b (14)	0.96	0.9268	0.9999

Note: In brackets are the numbers of the parameters as they are indexed in Figures C.1-C.3.

Comparative static characteristics are presented by graphical means in Figures C.1-C.3. These pictures show the impact of the respective parameters on the endogenous variables under consideration. Starting from the base-line, the figure reveals what values the endogenous variables take when one parameter of interest deviates from its base-line value. In the figures we put the value of the endogenous variable under consideration on the vertical axis. On the horizontal axis we depict the value of the parameter under consideration as a proportion of its base-line value (assuming all other variables remain unchanged).

Figure C.1 Relative wage *Figure C.2 Unemployment* *Figure C.3 Growth rate*

Blocked entry

In Table C.2 we provide the comparative static characteristics, again based on numerical experimentation, for the regime of blocked entry.[25] The base-line parameters are as given in Table C.1, and the number of firms is taken to be equal to 11. Experimentation with other base-line parameters has confirmed that the qualitative results reported here are reasonably robust with respect to parameter changes. For each set of parameter values, the values of g, U and ω are given, respectively (from top to bottom). So when all parameters are at their base-line value except for F which is at 80% of its base-line value, g=4.285%, U=4.347, and ω=1.069. Based on these results and additional sensitivity analysis, the conclusions of the derivatives of the growth-rate and the unemployment rate with respect to the respective parameters (indexed in general as x) are derived and presented in the last two columns.

The comparative statics results presented in Table C.2 are the outcome of various partly offsetting and interacting effects. In general, factors that tend to increase firm size either by

[25] More detailed information on the effects of parameter changes on the other endogenous variables of the model is available upon request.

reducing unemployment (b or ω decreases), increasing the relative size of the high-tech sector (ω decreases, σ increases), or which leave more labour within the firm for productive purposes (F decreases), put an upward pressure on the growth rate. The growth rate, the size of the high-tech sector and the relative wage rate in turn simultaneously (and positively) affect unemployment. Combining these effects explain the resulting outcomes. For an extensive discussion of the results with respect to b and γ_2 we refer to the main text. The comparative static results w.r.t. F are broadly similar to those w.r.t. b, except for ω. This is explained since an increase in the unemployment benefit unambiguously results in a declining firm size which results in firms employing less monitoring labour and increasing the non-competitive wage premium. In our example, the increase in the fixed cost requirement increases firm size and thereby increases the monitoring intensity and reduces the non-competitive wage differential.

Table C.2 Comparative statics in blocked entry regime

	-60	-20	-1	-0.5	Base	+0.5	+1	+20	dg/dx	dU/dx	dω/dx
		4.285	4.230	4.229	4.227	4.226	4.225	4.170	-		
F	n.a.	4.347	4.576	4.583	4.589	4.595	4.601	4.832		+	
		1.069	1.069	1.069	1.069	1.069	1.069	1.068			-
	4.278	4.173	4.223	4.225	4.227	4.230	4.232	4.349	v		
γ_2	5.381	6.054	4.688	4.639	4.589	4.537	4.485	1.975		n	
	1.074	1.075	1.069	1.069	1.069	1.068	1.068	1.058			n
			4.468	4.363	4.227	4.048	3.797		-		
b	U<0		0.128	2.083	4.589	7.920	12.567	b>1		+	
			1.066	1.067	1.069	1.071	1.074				+

Note: A 'v' in the last columns indicates that the derivative has an U-shaped pattern while a 'n' indicates that it has an inverted U-shaped pattern. The plus- and the minus signs indicate that the derivatives are positive and negative, respectively.

References

Akerlof, G.A. (1982), 'Labor Contracts as Partial Gift Exchange', *Quarterly Journal of Economics*, 97, pp. 543-69.

Arai, M. (1994), 'An Empirical Analysis of Wage Dispersion and Efficiency Wages', *Scandinavian Journal of Economics*, 96, pp. 31-50.

Bean, C.R. and C. Pissarides (1993), 'Unemployment, Consumption and Growth', *European Economic Review*, 37, pp. 837-59.

Bowles, S. (1985), 'The Production Process in a Competitive Economy: Walrasian, Neo-Hobbesian, and Marxian Models', *American Economic Review*, 74, pp. 16-36.

Brown, C. and J. Medoff (1989), 'The Employer Size - Wage Effect', *Journal of Political Economy*, 97, pp. 1027-59.

Bulow, J.I. and L.H. Summers (1986), 'A Theory of Dual Labor Market with Application to Industrial Policy, Discrimination, and Keynesian Unemployment', *Journal of Labor Economics*, 4, pp. 376-414.

Burda, M. (1988), '"Wait Unemployment" in Europe', *Economic Policy*, 7, pp. 391-425.

Calvo, G. (1978), 'Urban Unemployment and Wage Determination in LDC's: Trade Unions in the Harris-Todaro Model', *International Economic Review*, 19, pp. 65-81.

Danthine, J.P. and J.B. Donaldson (1990), 'Efficiency Wages and the Business Cycle Puzzle', *European Economic Review*, 34, pp. 1275-1301.

Dickens, W.T. and L.F. Katz (1987), 'Inter-Industry Wage Differences and Industry Characteristics', in: K. Lang and J.S. Leonard (eds), *Unemployment and the Structure of Labor Markets,* New York, Basil Blackwell.

Dixit, A. and J.E. Stiglitz (1977), 'Monopolistic Competition and Optimum Product Diversity', *American Economic Review*, 67, pp. 297-308.

Fehr, E., G. Kirchsteiger and A. Riedl (1993), 'Does Fairness Prevent Market Clearing? An Experimental Investigation', *Quarterly Journal of Economics*, 108, pp. 437-59.

Gali, J. (1995), *Non-Walrasian Unemployment Fluctuations*, NBER Working Paper, 5337, National Bureau of Economic Research, Cambridge, MA.

Gera, S. and G. Grenier (1994), 'Interindustry Wage Differentials and Efficiency Wages: Some Canadian Evidence', *Canadian Journal of Economics*, 27, pp. 81-100.

Groot, H.L.F. de and A.B.T.M. van Schaik (1998), 'Growth and Unemployment in a Dual Economy', Tilburg University, Tilburg, mimeo.

Harris, J.R. and M.P. Todaro (1970), 'Migration, Unemployment and Development: A Two-sector Analysis', *American Economic Review*, 60, pp. 126-42.

Kahneman, D., J.L. Knetsch and R. Thaler (1986), 'Fairness as a Constraint on Profit Seeking: Entitlements in the Market', *American Economic Review,* 76, pp. 728-41.

Kletzer, L. (1992), 'Industry Wage Differentials and Wait Unemployment', *Industrial Relations*, 31, pp. 250-69.

Krueger, A.B. and L.H. Summers (1988), 'Efficiency Wages and the Inter-industry Wage Structure', *Econometrica*, 56, pp. 259-93.

Lazonick, W. (1991), *Business Organization and the Myth of the Market Economy*, Cambridge, Cambridge University Press.

Lindbeck, A. and D.J. Snower (1991), *Segmented Labour Markets and Unemployment*, CEPR Discussion Paper, 523, Centre for Economic Policy Research, London.

McCormick, B. (1990), 'A Theory of Signalling during Job Search Employment Efficiency, and "Stigmatised" Jobs', *Review of Economic Studies*, 57, pp. 299-313.

Nickell, S. and R. Layard (1997), *Labour Market Institutions and Economic Performance*, Discussion Paper Series on The Labour Market Consequences of Technical and Structural Change, Oxford.

OECD (1994), *The OECD Jobs Study; Evidence and Explanations, Parts I and II*, Paris, OECD.

Pissarides, C.A. (1990), *Equilibrium Unemployment Theory*, Cambridge, MA, Basil Blackwell.

Reenen, J. van (1996), 'The Creation and Capture of Rents: Wages and Innovation in a Panel of U.K. Companies', *Quarterly Journal of Economics*, 111, pp. 195-226.

Schaik, A.B.T.M. van and H.L.F. de Groot (1998), 'Unemployment and Endogenous Growth', *Labour*, 12, pp. 189-219.

Solow, R.M. (1980), 'On Theories of Unemployment', *American Economic Review*, 70, pp. 1-11.

Taubman, P. and M.L. Wachter (1986), 'Segmented Labor Markets', in: O. Ashenfelter and R. Layard (eds), *Handbook of Labor Economics Vol.2,* Amsterdam, Elsevier Science Publishers.

Unemployment, Growth and Efficiency Wages

Figures

Henri L.F. de Groot

Vrije Universiteit
De Boellaan 1105
1081 HV Amsterdam
The Netherlands

Anton B.T.M. van Schaik

Tilburg University
PO Box 90153
5000 LE Tilburg
The Netherlands
schaik@kub.nl

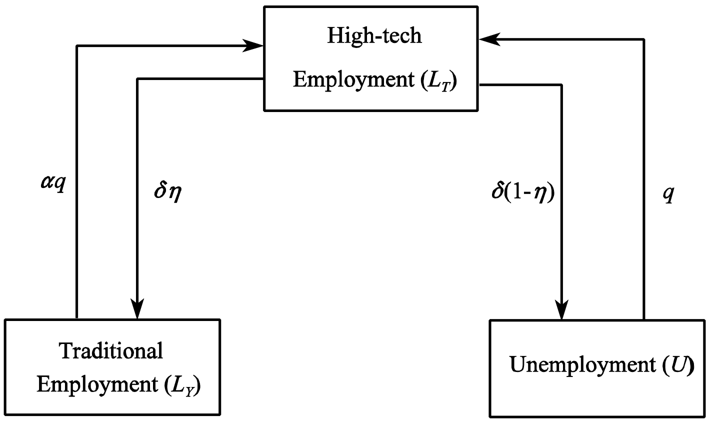

Figure 1

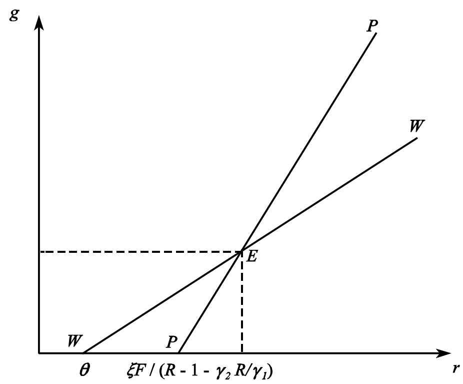

Figure 2

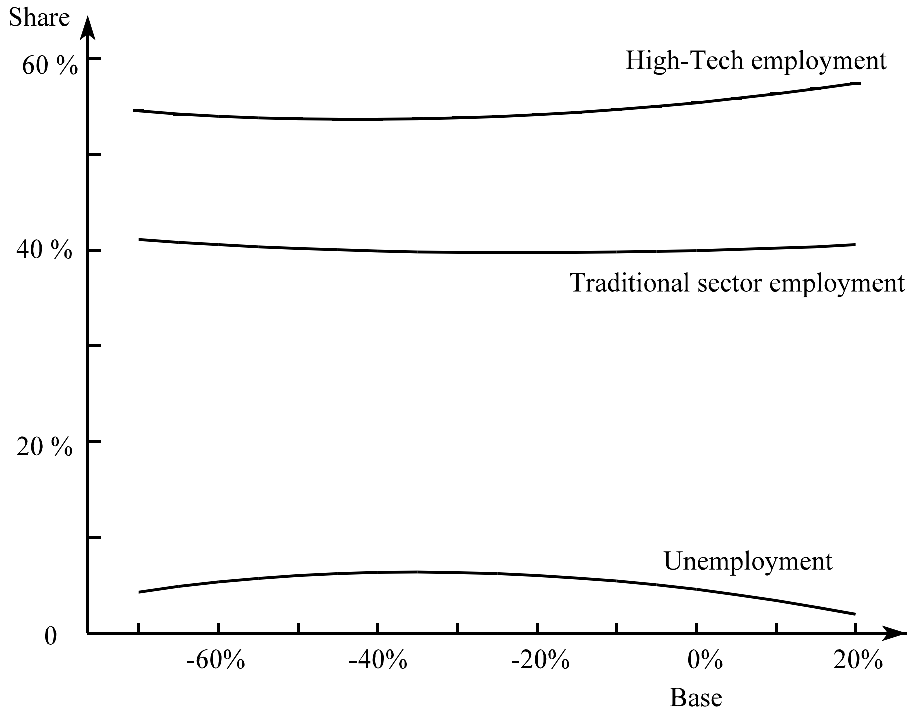

Figure 3a

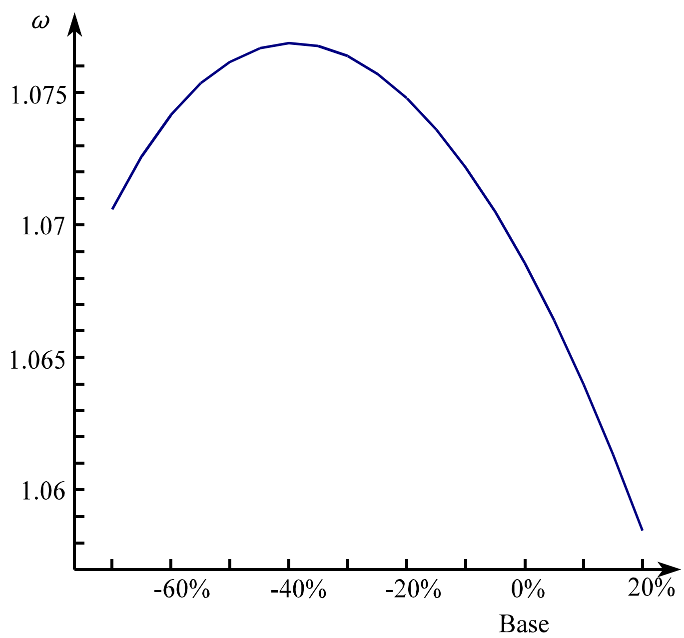

Figure 3b

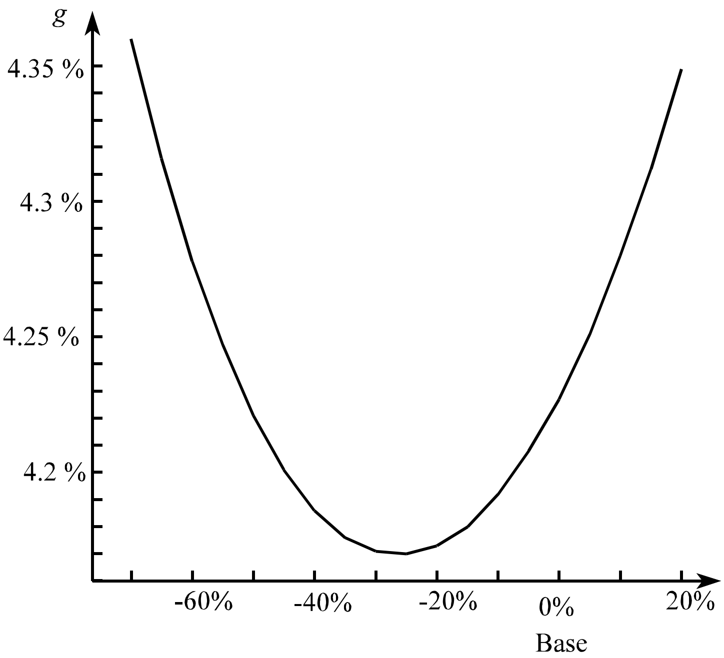

Figure 3c

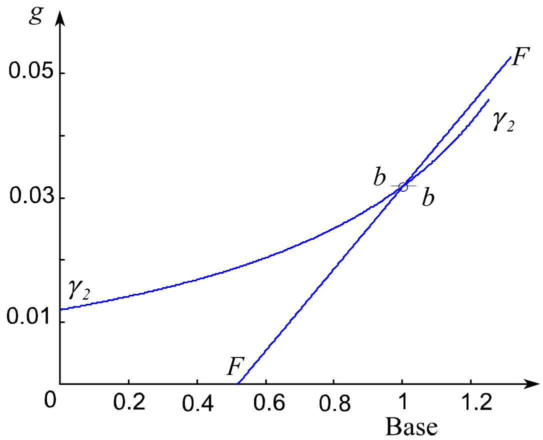

Figure C 1

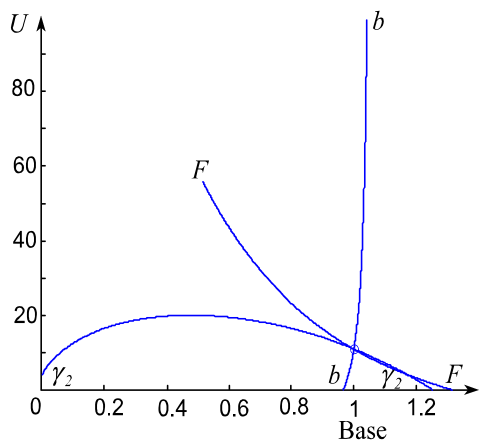

Figure C 2

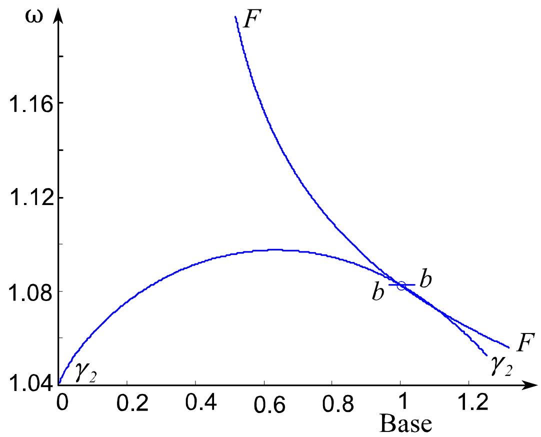

Figure C 3